3446

Field Tests of the Reverse Osmosis Unit for Concentrating Maple Sap

J. C. Underwood, J. C. Kissinger, and R. A. Bell
Eastern Utilization Research and Development Division
Agricultural Research Service
United States Department of Agriculture
600 East Mermaid Lane
Philadelphia, Pennsylvania 19118

Laboratory scale studies in 1966-67 (1) showed that the reverse osmosis (RO) process could be used to concentrate maple sap. These experiments demonstarted that (a) maple flavor precursors do not pass through the membrane, (b) up to 75% of the sap water can be efficiently removed at an estimated energy cost of about 1/20 of that for thermal distillation, and (c) the removal of the remainder of the water can be done by the conventional heat process to produce typical maple flavor and color.

Based upon these observations and data, a semi-plant size reverse osmosis concentrator (EUROC, Fig. 1) was constructed for field tests (2). The main objectives of the field tests were to (a) determine the effect of the reverse osmosis on quality of sirup, (b) observe the performance of the EUROC for long periods of continuous operation with maple sap, and (c) determine the cleaning procedures needed to maintain the membranes in efficient operating condition for prolonged use.

In 1968 the first field tests were conducted at the central plant of Lloyd Sipple at Bainbridge, New York (3). Two studies were run. The most important fact to be determined was whether RO-concentrated sap would yield a sirup with full-bodied flavor and no off-flavors when concentrated to standard density sirup by conventional open pan evaporators. This was done by running 500 gallons from a uniformly mixed 4000 gallons of maple sap through the EUROC at 600 psig at a feed rate of 5 gal./min. The treated sap was then boiled to sirup density in the plant's evaporator pans. This sirup had a full-bodied flavor and could not be differentiated from the sirup made from the remainder of the 4000 gallons by the plant's conventional procedure. Then the RO unit was operated for the rest of the abnormally short season as part of the plant's processing procedure. Ten thousand gallons of sap were treated by EUROC at 5 gal./min. and 600 psig, removing 50% of the water from the feed. At no time was there evidence in the finished sirup of any deleterious effect due to the reverse osmosis treatment. One of the important factors that will determine the economic feasibility of reverse osmo-

sis for maple sap concentration is life of the membranes. To protect the membranes in EUROC from deterioration by microorganisms normally present in the raw sap, the feed line is equipped with in-line ultraviolet water sterilizing units. This treatment of the feed minimized the build-up of bacteria, yeasts, or molds in the various lines and pressure vessels of the unit during extended use. Also, when EUROC was shut down more than 24 hours, it was found necessary to drain the sap from the unit, sanitize it with a hypochlorite solution acidified to pH 4.5 with acetic acid, and flush out the excess chlorine with water sterilized by passing it through the ultraviolet feed line purifier (4). Otherwise, an excessive bacterial build-up occurred in the pressure tubes during shut-down.

Second Season, 1969

For the 1969 season, the EUROC was taken to Mountain Meadow Farm, Schellsburg, Pennsylvania to the central plant of B. F. Walters. One change was made in the unit for this, the second year of field tests. Late in 1968 a new membrane module became available. This module is three feet long compared to the one foot length of the older ones. The new type, also, was improved in construction to give increased flux and longer life. For the 1969 tests two of the eight pressure tubes of EUROC were filled with the 3-foot modules. The unit was again test run by EURDD personnel and then operated by plant personnel for the season with weekly check visits. The unit was operated at a speed rate of 6 gal/min. at 550 pounds applied pressure. With the new modules these conditions removed 50% of the water from the feed. During a 4-week period over 50,000 gallons of sap passed through the unit. The first two weeks of the active season the unit worked well.

Then the amount of water being removed began to decrease (flux dropped). The fall in flux continued until only 33% of the feed water was being removed. The selectivity of the membranes remained unchanged as indicated by conductivity and sugar values of the permeate. A pressure tube was opened and the cause of the flux decline was very evident. Slime was depositing on and in the modules. Cleaning by flushing with water and enzymic detergents produced only a temporary small improvement.

The unit was brought to the laboratory at the end of the season and studies made to find a method of preventing and/or removing the slime buildup.

It was observed that the new 3-foot modules were much freer of slime than the old 1-foot ones. As the flux of the 3-foot modules had been determined to be 50% greater than the shorter ones, the flow rate of the feed through the pressure tubes with the longer module had to be greater than with the shorter modules. Increased flow rate might eliminate slime deposition.

The slime seemed to come from the feed water; it was not being produced in the pressure tubes. The bacteria counts of the concentrate discharge did not indicate high microorganism activity around the membranes. Trouble did begin when the sap temperature would rise due to warm weather. This indicated a possible increase in polysaccharide production by adventitious microorganisms contaminating the sap. The flux of the modules returned to normal after several periods of inactivity and water flushing of the unit. Various enzymatic treatments did little good.

Work for the 1970 season indicated by these findings was to study the effect of increased feed flow rate on the slime deposition and find the source of the slime.

$ FOR THE DIGEST

Third Season, 1970

The EUROC was operated again during the 1970 maple season at B. F. Walters' Mountain Meadow Farm, Schellsburg, Pennsylvania. The unit was run at this plant for a second consecutive year because Mr. Walters, being very much interested in the reverse osmosis process, generously furnished a number of the new 3-foot membrane modules for the unit. With the 3-foot modules it was possible to arrange the pressure tubes in a group of four parallel two-tube units con-

seasons because the three-foot module that has replaced the one-foot type was improved in construction specifically for longer life. Field testing of these must continue if their life is to be determined.

References

1. Willits, C. O., Underwood, J. C. and Merten, U. Concentration by reverse osmosis of maple sap. Food Technol. 21, 24-26 (1967).
2. Moore, W. H., Jr. and Willits, C. O. A reverse osmosis plant for maple sap concentration. U. S. Agr. Research Service, ARS 73-66, 13pp. (1970).
3. Underwood, J. C. and Willits, C. O. Operation of a reverse osmosis plant for the partial concentration of maple sap. Food Technol. 23, 787-790 (1969).
4. Kissinger, J. C. and Willits, C. O. Preservation of reverse osmosis membranes from microbial attack. Food Technol. 23, 481-484 (1969).